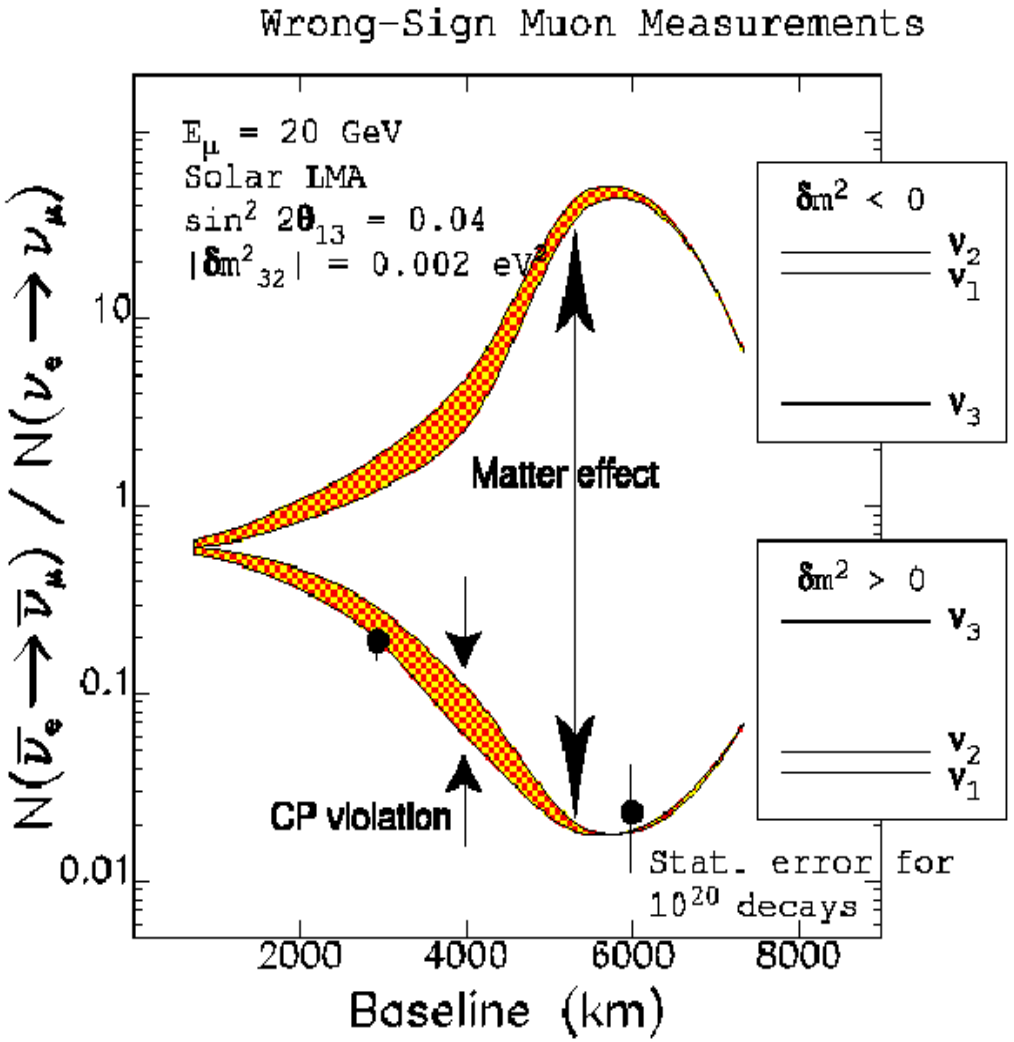
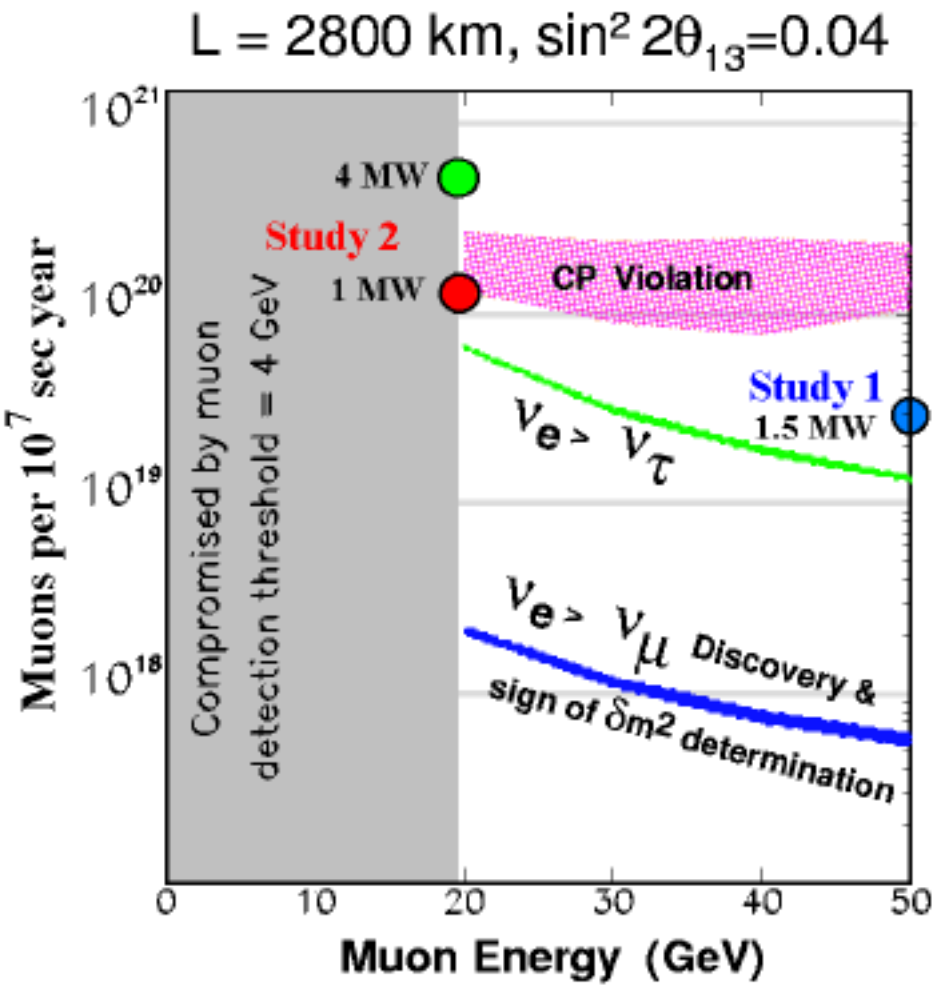
Neutrino Factory Physics Reach

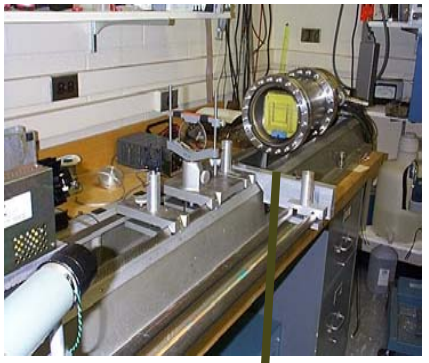




- By measurement of wrong-sign muon appearance from initial ν_e beam, stored-muon-beam Neutrino Factory can shed unique light on
  - lepton mixing
  - CP violation
  - baryogenesis

MUCOOL R&D Efforts

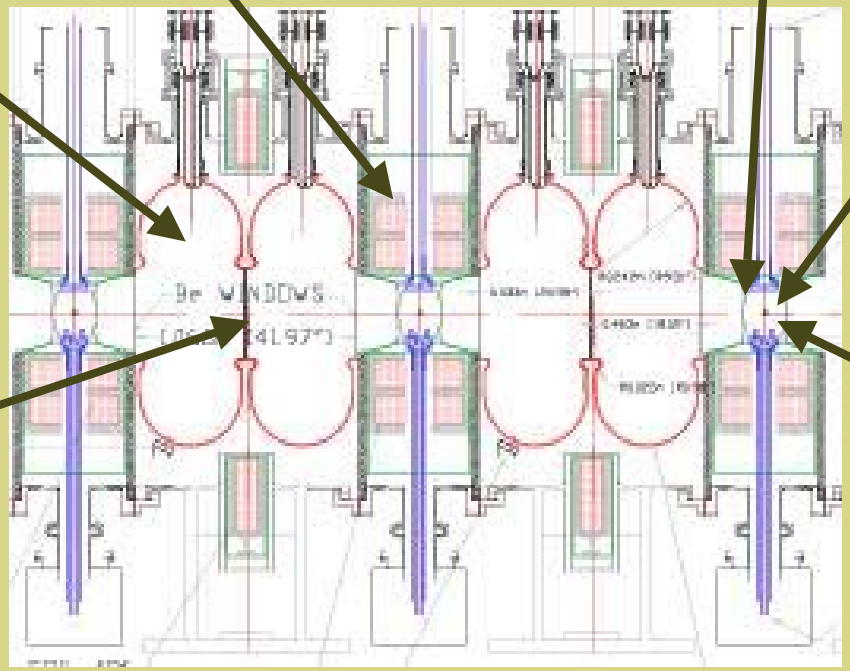
5T cooling-channel solenoid (LBNL)
Open-cell NCRF cavity operated at Lab G (FNAL)

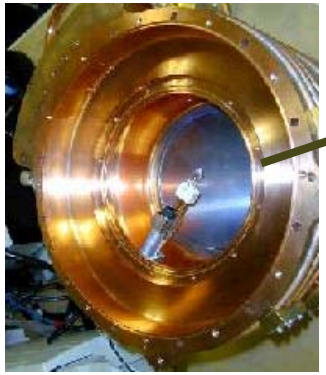


Bolometer detectors for beam-profile measurements (U. Chicago)

High-gradient RF tests in high magnetic field (FNAL)

LH_2 absorber (KEK) to be tested at FNAL





Be windows for RF Cavities (LBNL)

Thin absorber windows tested with new technique (ICAR)

Illinois Consortium for Accelerator Research

- 5-university consortium, founded 1999, led by IIT

D. M. Kaplan (IIT), PI; T. I. Morrison (IIT), PD

- Responds to looming crisis in sustaining progress of accelerator-based particle physics
- Includes >10 faculty, >30 researchers
- Main funding: 5-year State of Illinois grant at $2.5M/year
- Main research activities: Linear Collider, MUCOOL (12 FTE)
- Close collaboration with Fermilab

MUCOOL Test Facility

- Need facility in which to test
  - absorbers
  - RF cavities
  - solenoids
- Show cooling cell operable in intense beam
  (engineering test, not cooling demo)
- ∃ convenient location: end of Linac has
  - space
  - 201 & 805 MHz RF power sources
  - 400 MeV beam

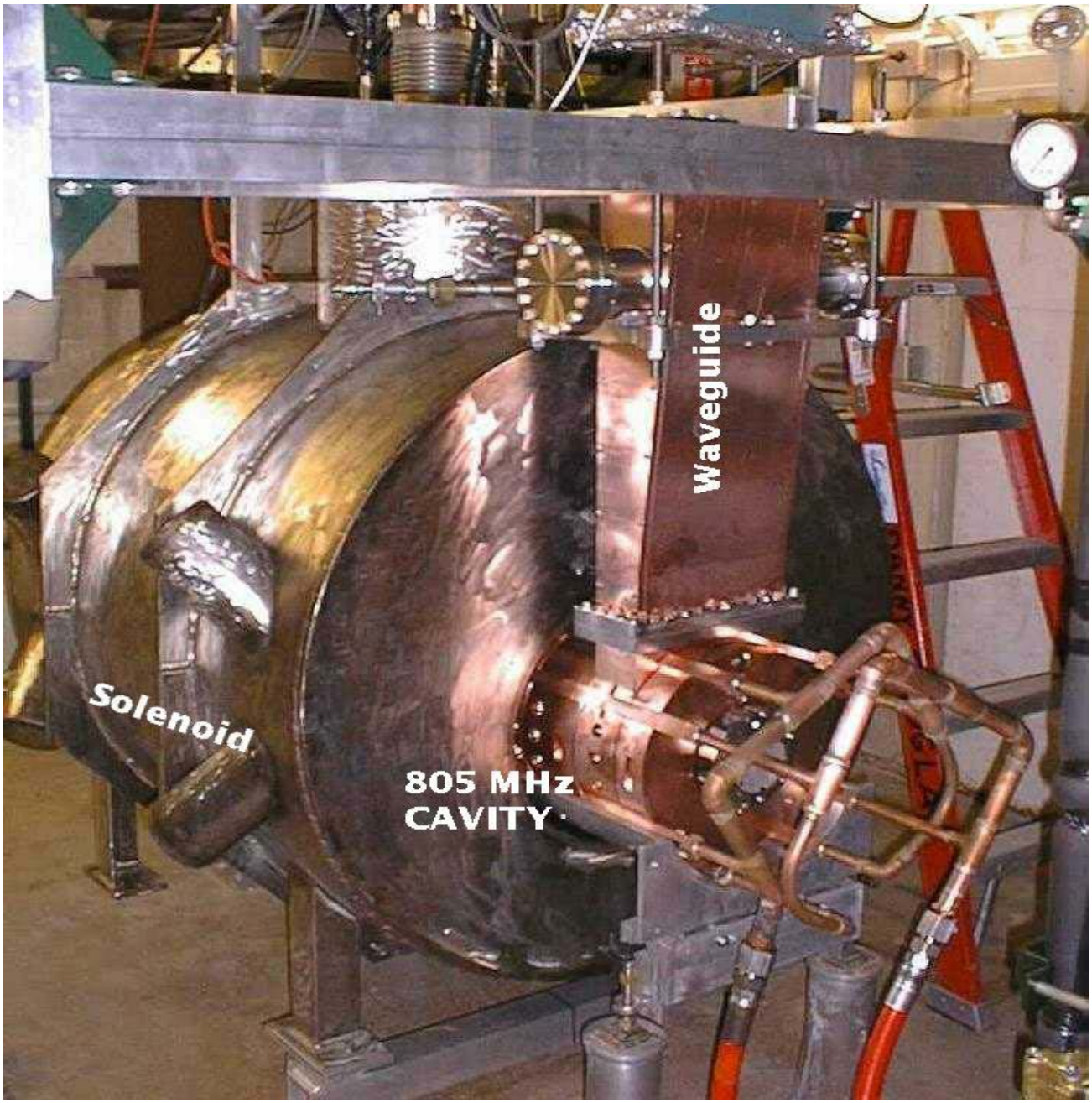
High-Gradient RF R&D

ANL / FNAL / IIT / LBNL / UMiss

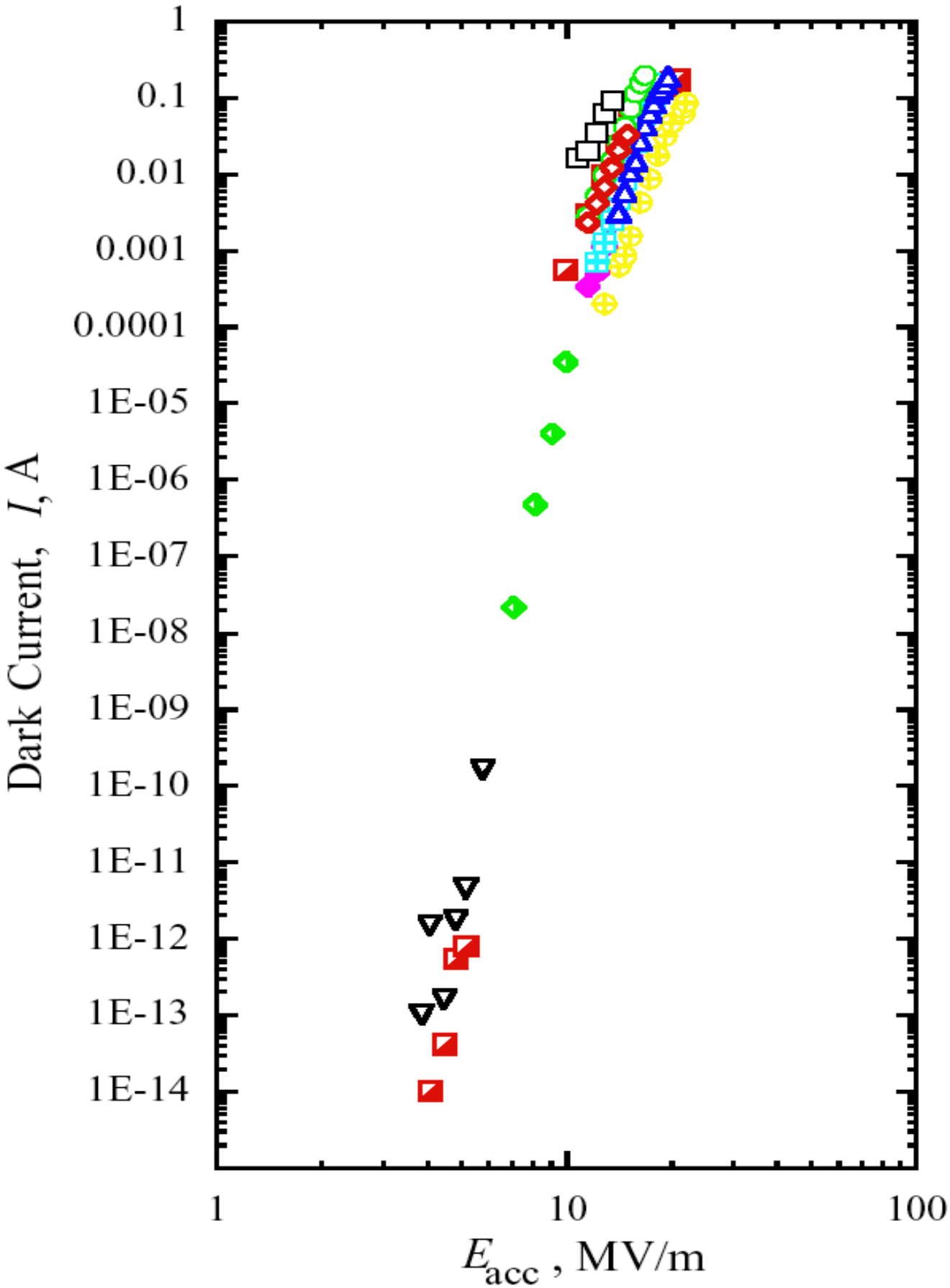
High-Gradient-RF-Cavity R&D

- U. Cincinatti Ph.D. student Vincent Wu tuning the prototype 805-MHz open-cell cavity

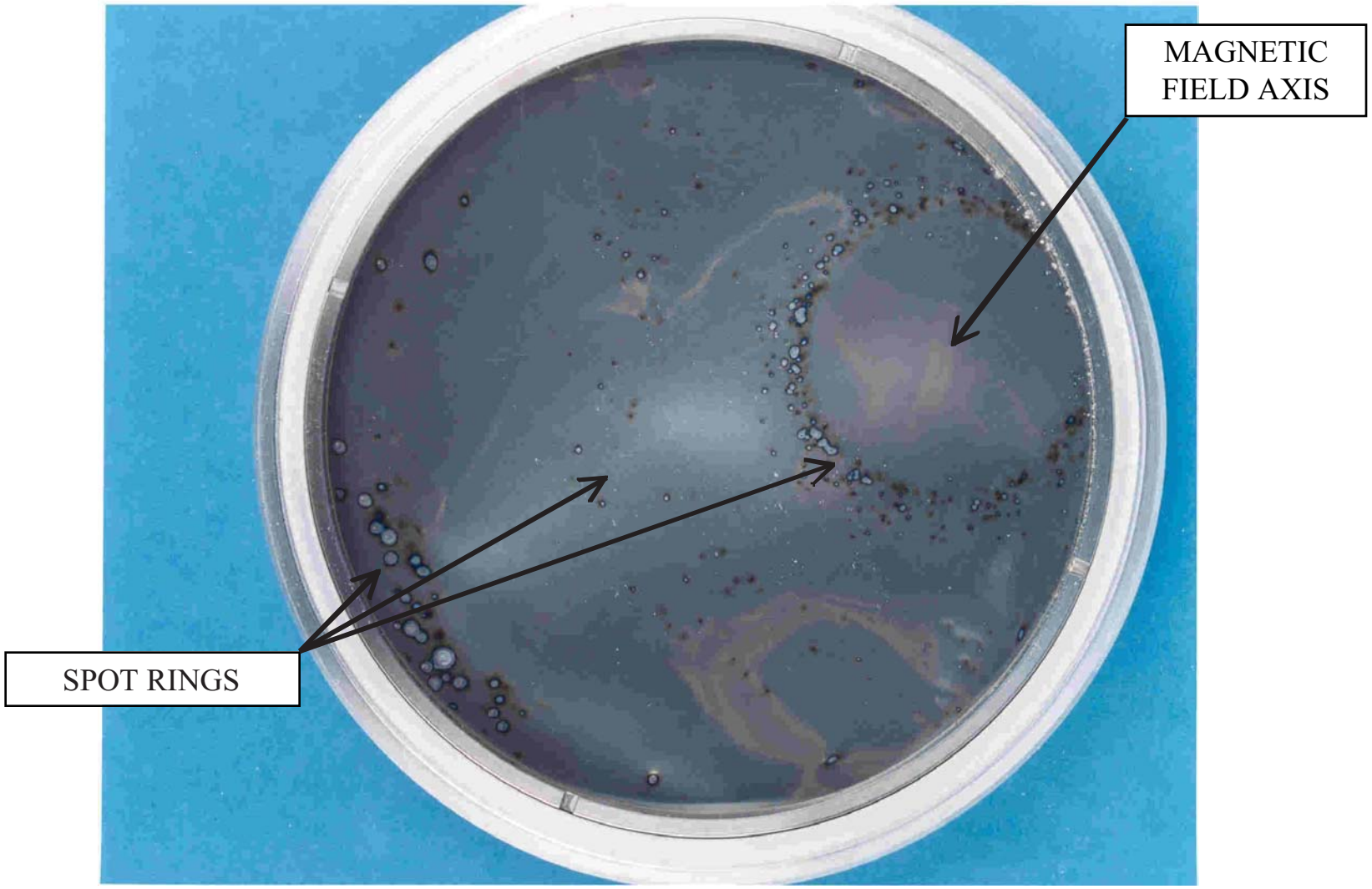
- Open-cell 805-MHz prototype cavity in superconducting solenoid in Lab G



- See large dark current at high gradients:

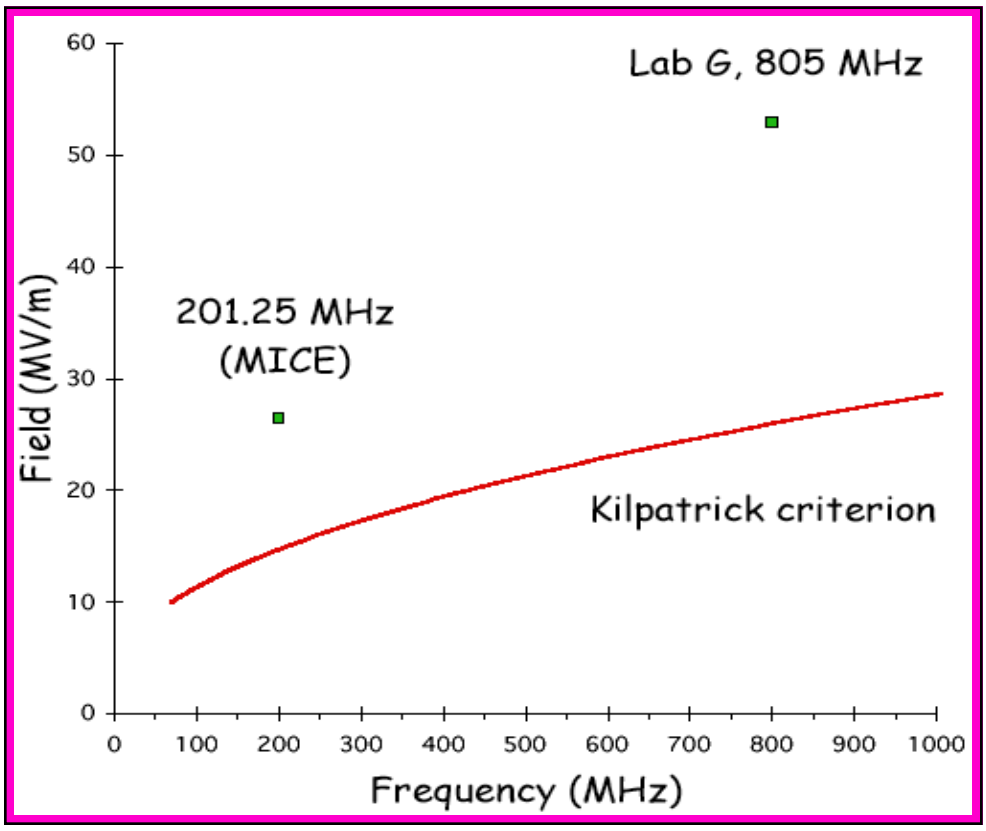


Spark Damage on Inside of Cavity Window



RF R&D Achievements:

- Reached regime of surface electric field (50 MV/m) needed for FS-II cooling channel, with solenoidal magnetic field up to 2.5 T



- Sparking & dark currents require R&D on surface quality and treatment
  - issues common to NLC
- LBL closed-cell-cavity prototype now installed in Lab G for high-power tests
  - RF cells closed by beryllium windows
  - gives 2× lower power requirement & surface field for same accelerating gradient

Simulation

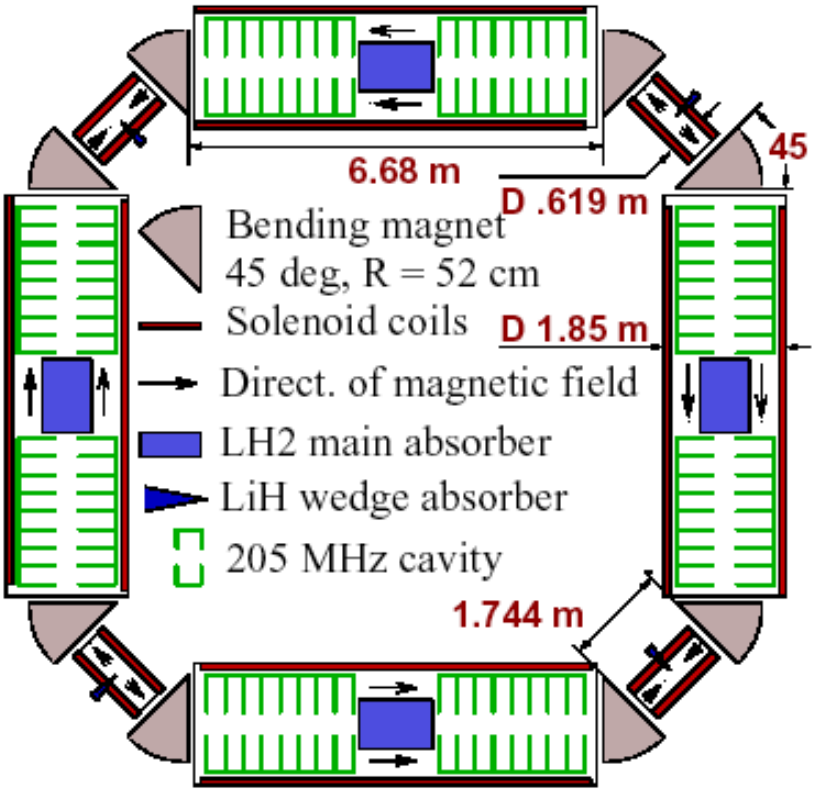
BNL / FNAL / IIT / IU / UIUC

MUCOOL Simulations:

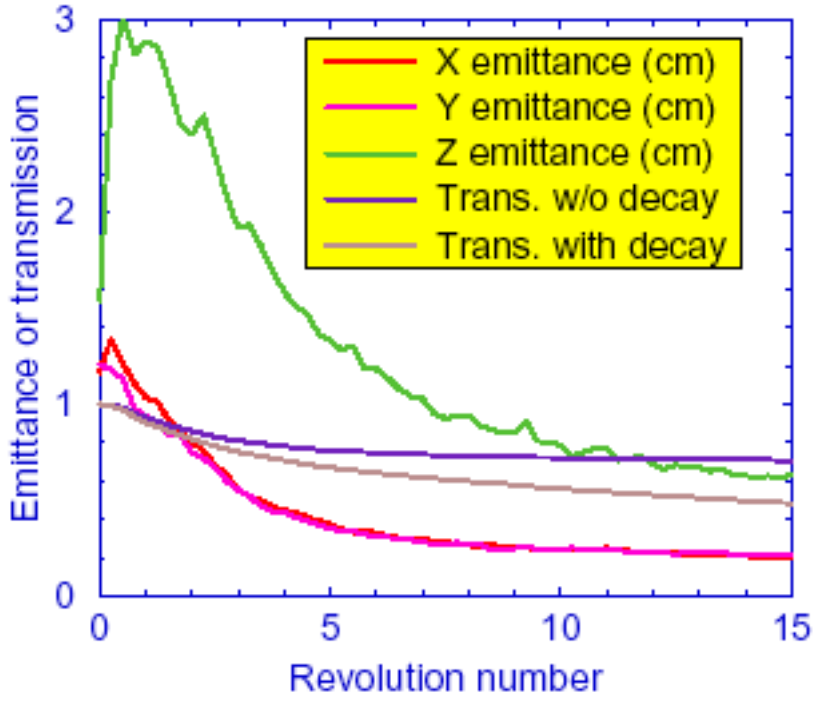
- FS-II demonstrated successful high-intensity Neutrino Factory design
- Our current focus:
  - Reduce cost
  - Develop longitudinal cooling (opens door for Muon Colliders)
  - Develop cooling demonstration (MICE)
- Projects:
  - Bunched-beam phase rotation
  - MICE experiment simulation
  - Quadrupole-focused cooling channel
  - Ring coolers & emittance exchange

Balbekov Ring Cooler

V. Balbekov, R. Raja, Z. Usubov (FNAL)



- Cools longitudinally as well as transversely
- Can reduce cooling cost
- Injection, extraction yet to be worked out



- Performance characterized using GEANT

Bunched-Beam Phase Rotation

(High-frequency muon capture)

D. Neuffer, A. van Ginneken, D. Elvira (FNAL)

- Motivation:

  Induction Linac requires new technology and is too expensive

- Alternative Scenario:

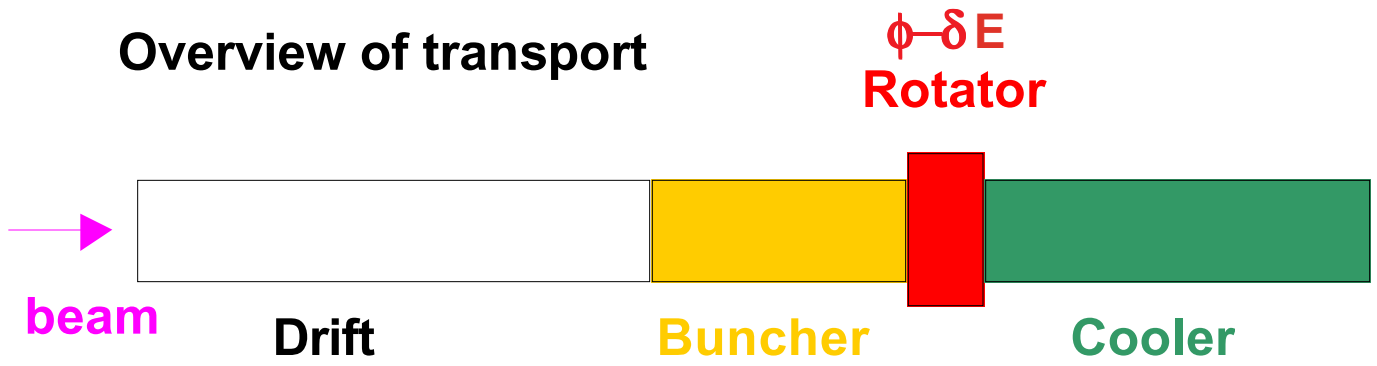
  Use low-cost ≈200 MHz RF for μ capture

  Requires sequence of RF at several frequencies to trap μ beam into string of 200 MHz bunches

- Results:

  ~0.4 μ/p (each sign) captured for ν-factory
  μ^+ and μ^- bunches obtained simultaneously

Bunched-Beam Phase Rotation - layout



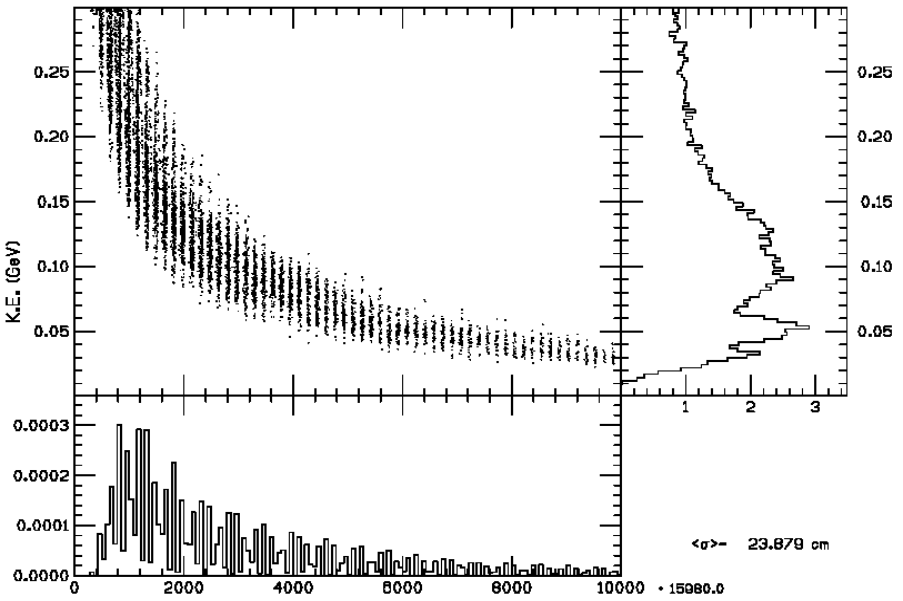
- **Drift (100m)**
  Allows $\pi \rightarrow \mu$ decay; beam develops ϕ–δE correlation

- **Buncher (60m) 300→200MHz, V′ = 0→4.8 MV/m**
  E_0 = 125±50 MeV set at 15 λ separation;
  beam forms into string of bunches of different energies

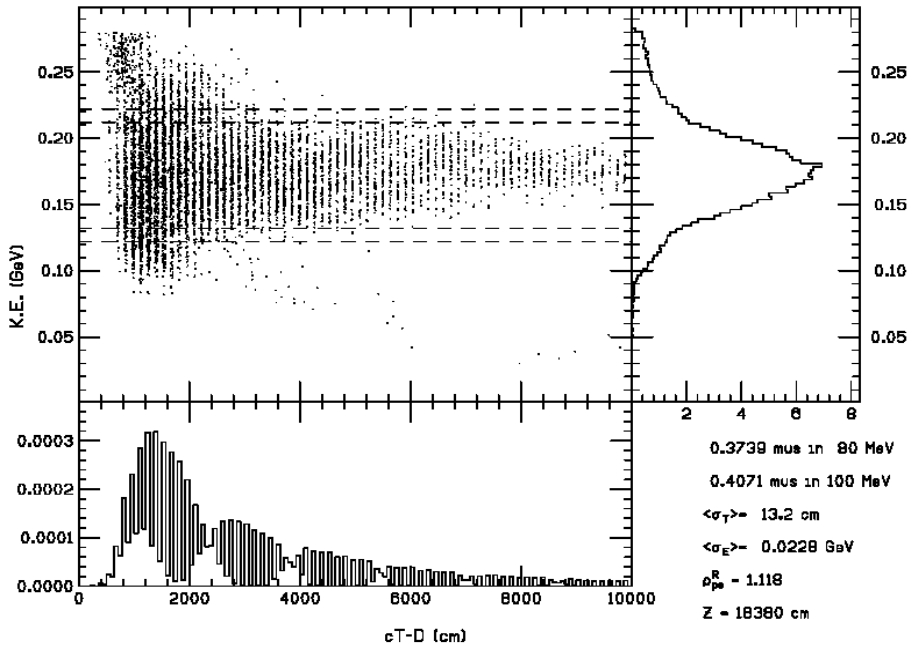
- **ϕ–δE Rotator (~10m) ~200MHz, V′ = 10 MV/m**
  Beam rotates by ~1/4 ϕ–δE oscillations;
  bunches align to similar energies

- **Cooler (100m) ~200MHz**
  Transverse cooling to reduce beam size

& performance



- After drift plus adiabatic buncher, beam formed into string of ≈200-MHz bunches



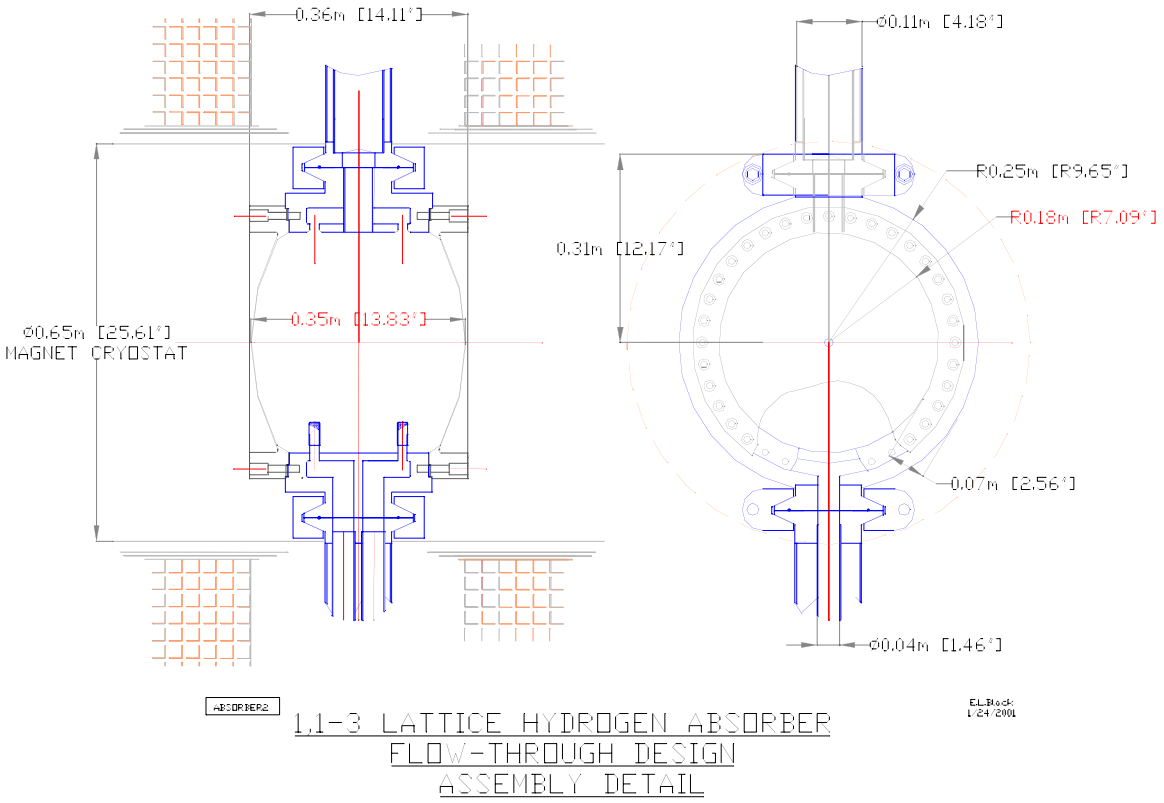
- After ≈200-MHz RF rotation, beam formed into string of equal-energy bunches matched to cooling RF acceptance

Absorber R&D

FNAL / IIT / KEK / NIU / Osaka / Oxford / UIUC / UMiss

Forced-Flow Absorber Design

External Heat Exchange:

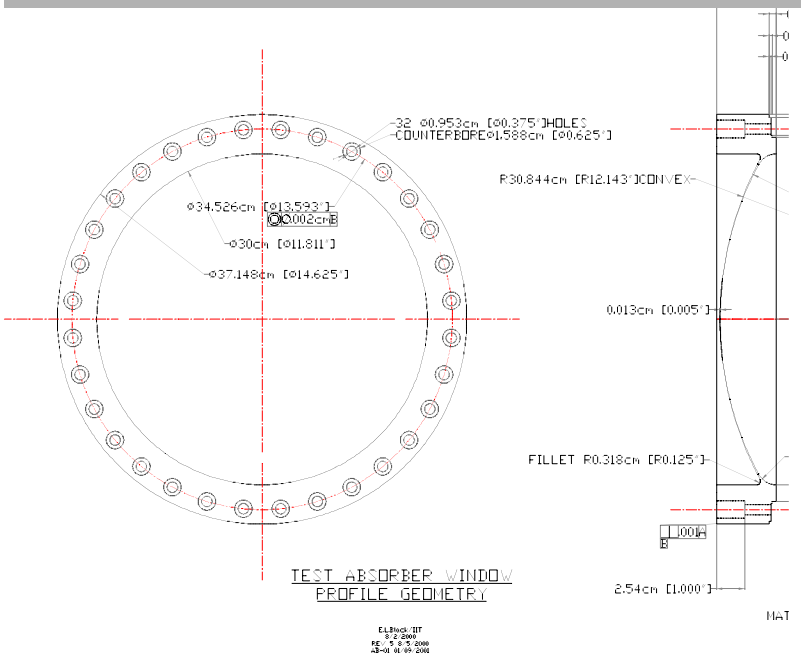


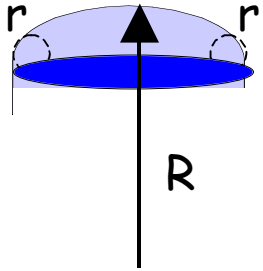
Mucool ~ (E. Black, IIT)
Establish transverse turbulent flow with nozzles – complicated, hard to simulate

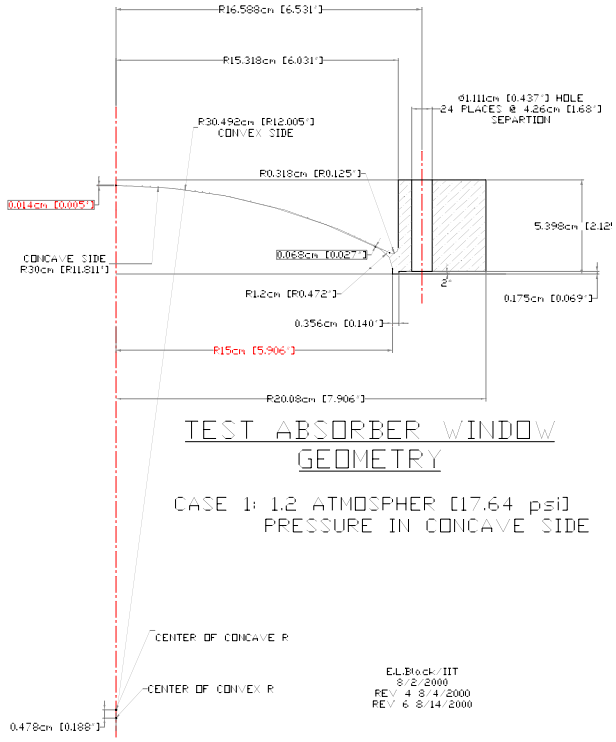
Absorber Window Design

Cooling channel requires minimum “heating”

- **Minimize scattering → minimize window thickness**
- **Modified Torispherical Integrated window and flange design**

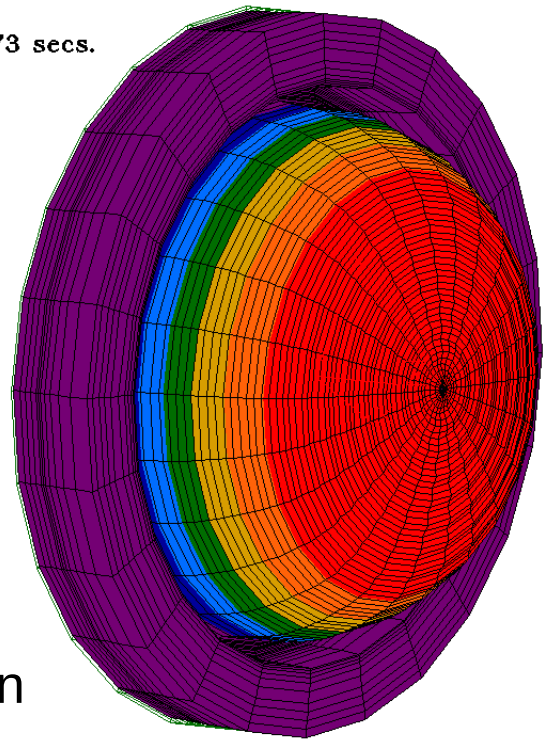






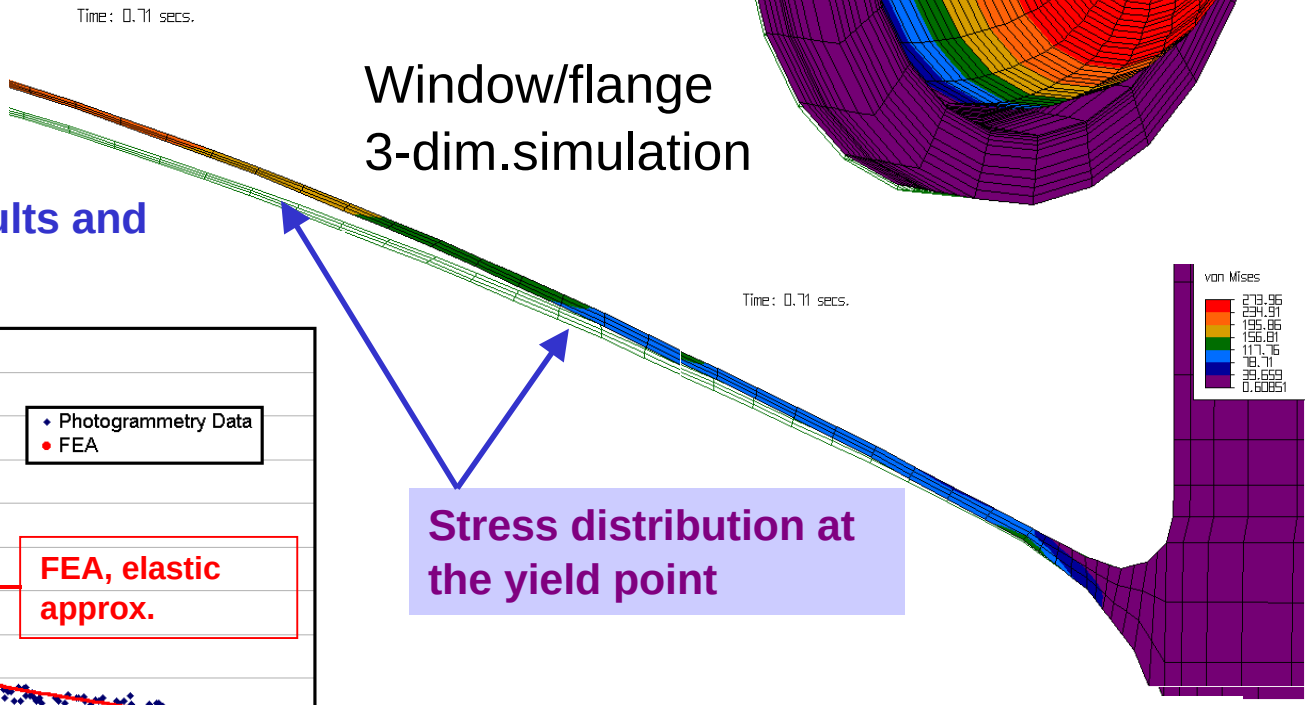
Modified torispherical integrated window and flange design (tapered detail at left).
Machine parameters shown.

FEA Calculations



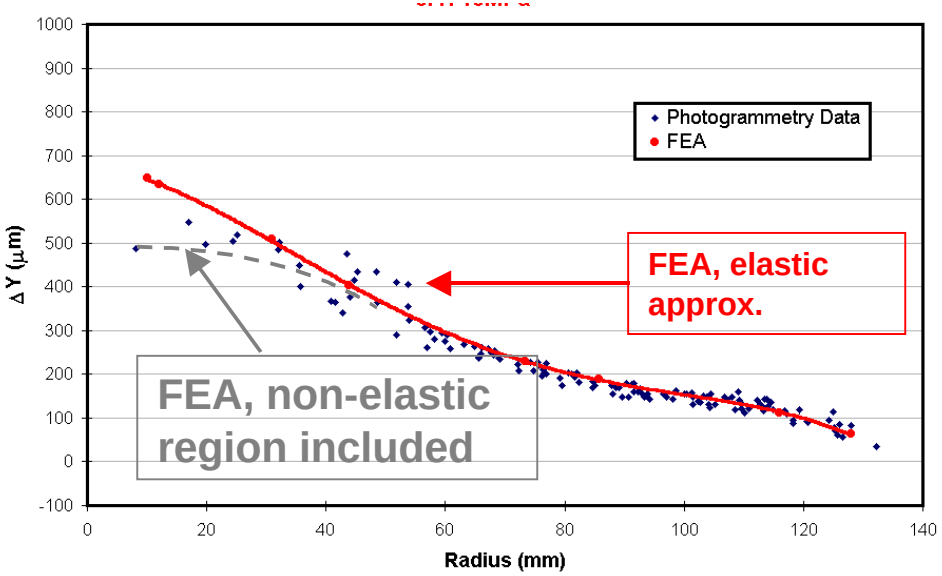
Finite Element Analysis

- Three dimensions necessary for vibrational analysis: on-elastic region included
- Displacement vs. radius under pressure



Window/flange
3-dim.simulation

NIU photogrammetry results and FEA calculations



Stress distribution at the yield point

Window/flange cross section

Absorber windows

Flange/window unit machined from aluminum piece

Backplane with connections, and with window attached

Photogrammetry test at NIU

Window with reflective coating and stationary targets

The new pattern: radial geometry

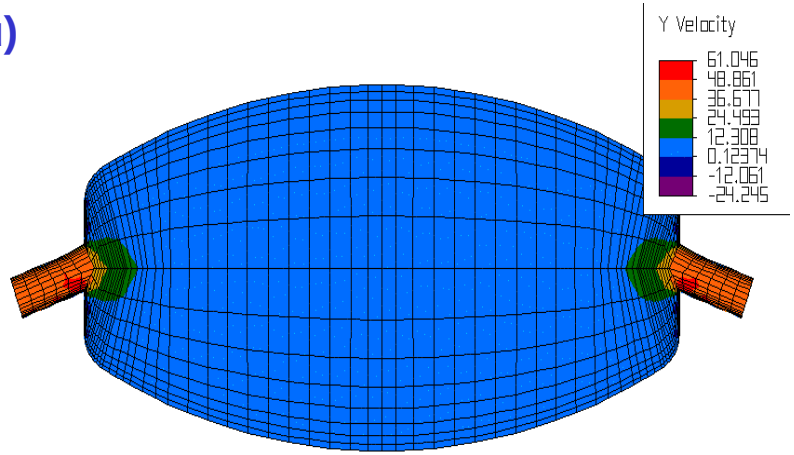
Photogrammetry setup for pressure testing (old pattern:cartesian)

Camera

Photostrobic projector

Flow Tests

Three dimensional LH2 absorber flow simulations (W. Lau)



Testing 3-dimensional simulations with water flow test at NIU